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Lycopodiella ×gilmanii (Lycopodiaceae), a New Hybrid Bog Clubmoss from Northeastern North America

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ABSTRACT.—*Lycopodiella ×gilmanii* is described as a new hybrid from northeastern North America. It is the result of *L. appressa* × *L. inundata* as inferred from morphology and geography. A key is provided for *Lycopodiella* in northeastern North America that includes hybrids.

Lycopodiella sensu Holub is a distinctive, small genus of wetland clubmosses. It differs from all other genera of lycopods in possession of largely deciduous shoots that overwinter as turions and subpeltate sporophylls with a narrow, elongate, leaf-like apical portion. *Lycopodiella* is further characterized by hemisaprophytic gametophytes, subglobose sporangia, superficial horizontal shoots that normally produce unbranched upright shoots terminated by a single strobilus, and a base chromosome number of $x = 78$ (Bruce, 1975; Øllgaard, 1987; Wagner and Beitel, 1992).

Despite the fact there are only six known species of *Lycopodiella* in North America (Wagner and Beitel, 1993), the genus is complex. Factors such as cryptic and environmentally influenced morphology, extensive hybridization, and ploidy-level differences contribute to an often bewildering array of morphologies seen in regional collections. Bruce (1975) critically examined *Lycopodiella* in the southeast and Great Lakes regions of North America. Of great importance is that he documented the existence of diploid and tetraploid taxa. Further, he showed that two types of hybrids existed – those with well formed spores produced by species of similar ploidy level and those with malformed spores produced by species of different ploidy level. Though he also examined northeastern material for his study, only a few paragraphs were devoted to discussion of taxonomic problems in New England and maritime Canada. This paper describes a new hybrid that has caused substantial confusion in the literature and in herbarium collections.

Lycopodiella appressa (Chapman) Cranfill is one of the most distinctive species of bog clubmoss in North America. Oddly, it is also one of the more misunderstood taxa. Fernald (1950), for example, interpreted *L. inundata* (L.) Holub (using the name *Lycopodium inundatum* L.) as passing freely into *L. appressa* (using the name *Lycopodium inundatum* var. *bigelovii* Tuckerman). This statement is based on failure to recognize hybrid individuals, which obscure the morphological gap between *L. appressa* and *L. inundata*. These hybrids, noted from northeastern North America by Bruce (1975) and Gillespie (1962), have largely gone unnoticed in regional collections. Also, failure to recognize a consistent geographic cline in certain morphological characters

may have contributed to the problem. Northern *Lycopodiella* specimens are shorter, have thinner shoots, and produce fewer upright shoots compared with southern specimens.

Following the arguments of Wagner (1968), a binomial name is here provided for *L. appressa* × *L. inundata* in order to call attention to this hybrid and its contribution to the taxonomic difficulties faced by students of the genus.

Lycopodiella* ×*gilmanii A. Haines, ***hybr. nov.***—TYPE. USA: Connecticut., Tolland County: low, open, wet areas in abandoned borrow pit, Koller Wildlife Management Area, growing with *Lycopodiella appressa*, *Scirpus cyperinus*, *Muhlenbergia uniflora*, *Alnus incana* ssp. *rugosa*, and *Rhynchospora capitellata*, at ca. 122 m elevation, Tolland, 23 Oct 2001, *Haines and Mehrhoff s.n.* (holotype: GH). **Figs 1 and 2.**

Caulis horizontalis 0.9–1.5 mm latus, prostratus, folia 3.8–6 × 0.5–0.8 mm, dentibus marginalibus utrinque 0–3(–4). Caulis erectus 1 vel 2, 8–18.5 cm altus. Strobili 28–75 × (6–)7–12 mm, sporophyllis (4.6–)5–6.4(–7.1) × 0.5–0.75 mm, ascentibus, dentibus marginalibus utrinque 0–2.

Hybrid of *Lycopodiella appressa* and *L. inundata*. Horizontal stem prostrate, 7–21 cm long, 0.9–1.5 mm in diameter exclusive of the leaves. Leaves of the horizontal stem 3.8–6 mm long, with 0–3(–4) minute teeth per margin, leaves on the distal portion of stem with relatively more teeth. Upright shoot 1 or 2 per horizontal stem segment, 8–18.5 cm tall, the leaves with entire margins or those in the basal portion of shoot minutely toothed. Strobili (22–)24–75 mm long, (6–)7–12 mm wide, representing (20–)28–45 percent of the upright shoot height. Sporophylls with 0–2 slender teeth per margin, ascending (loosely appressed), (4.6–)5–6.4(–7.1) mm long, 0.5–0.75 mm wide. Spores mostly 48–53 μm, varying from ca. 5–90 percent malformed.

PARATYPES.—CANADA. **Nova Scotia:** Yarmouth County. Peaty and sandy margin of Salmon (Greenville) Lake, 25 Aug 1921, *Fernald and Long 23077* (GH); Sandy and cobbly beach of Cedar Lake, 6 Oct 1920, *Fernald and Linder 19567* (GH).

UNITED STATES. **Connecticut.** Fairfield County: Large colony in moist mossy area, coastal field, with others, 27 Sep 1940, *Eames 12049* (CONN, NEBC). New Haven County: In moist sandy place, Milford, 26 Sep 1908, *Blewitt 1183* (NEBC); Wet sandy soil by R.R. E of Towautic Sta., 9 Sep 1917, *Harger 6992* (NEBC). Tolland County: Koller Wildlife Area, borrow pit, Tolland, 10 Aug 1991, *Mehrhoff 14914* (CONN, NEBC); Wet area in ruts of abandoned road, on hillside mined for gravel, E side of Route 32, 0.6 km southbound from I-84 overpass, Willington, 23 Oct 2001, *Haines s.n.* (NEBC). **Maine.** Cumberland County: Seasonally wet floor of abandoned quarry north of Pleasant Street near Freeport town line, growing with *Lycopodiella inundata*, *Muhlenbergia uniflora*, and *Rhynchospora capitellata*, Brunswick, 7 Sep 2002, *Haines s.n.* (MAINE); Quaking bog, Cumberland, 6 Sep 1902, *Chamberlain s.n.*


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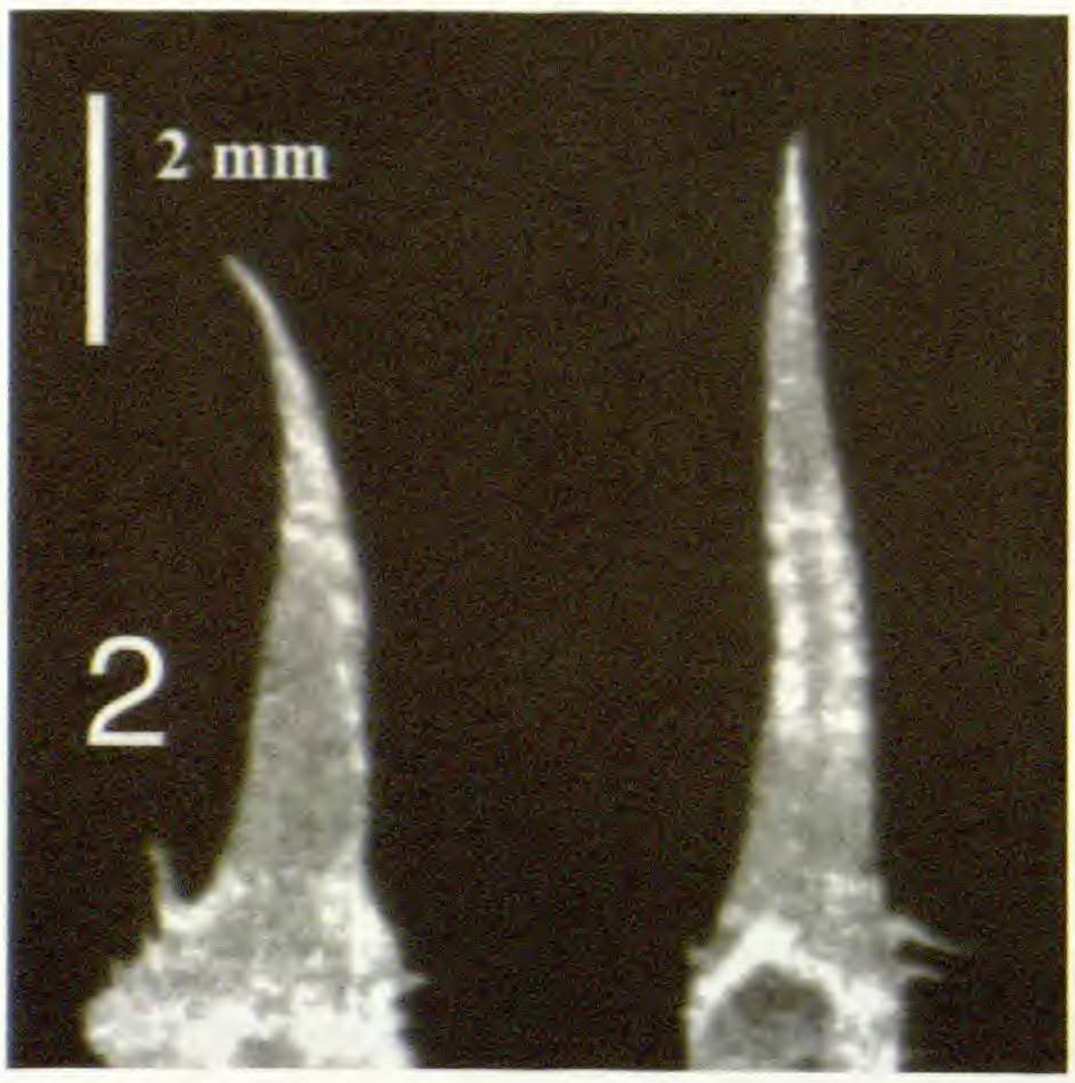
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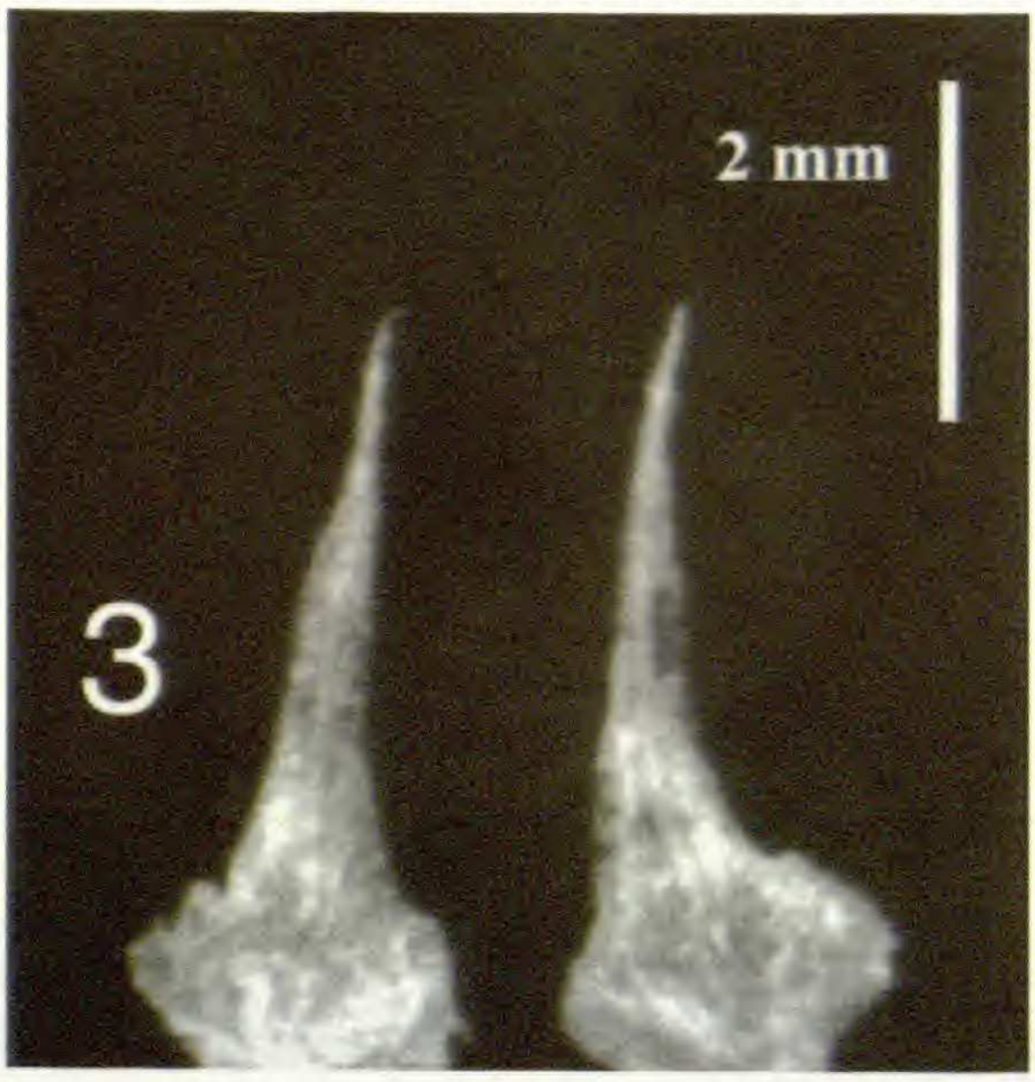
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(NEBC); Bog, The Meadow, Cumberland, 27 July 1903, *Chamberlain 484* (NEBC); Quaking bog, The Meadow, Cumberland, 12 Sep 1903, *Chamberlain s.n.* (MAINE); Sphagnum bog, Cumberland, 18 Aug 1900, *Chamberlain s.n* (BRU); Open, wet areas in a sandy depression, the surface covered by a thin layer of organic soil and/or *Sphagnum*, at 39 meters elevation, with *Muhlenbergia uniflora*, *Rubus hispidus*, *Drosera intermedia*, and *Viola lanceolata*, growing in close proximity to *L. inundata*, Falmouth, 2 Sep 2001, *Haines s.n.* (MAINE, NEBC). Hancock County: Aunt Betty Pond Road, Bar Harbor, 29 Aug 1908, *Rand s.n.* (MAINE). **Massachusetts.** Barnstable County: Damp sandy and peaty border of Israel Pond, Barnstable, 31 Jul 1913, *Fernald 8381* (GH). Bristol County: Open sandy swamp, North Easton, Easton, 2 Aug 1905, *Forbes s.n.* (CONN, NASC). Dukes County: McKinley Road bog, Marthas Vineyard, 23 Sep 1913, *Bicknell 11592* (NEBC); Cranberry Bog, Chillmark, 21 Sep 1916, *Seymour 1015* (GH). Hampden County: Wet sphagnous flat by gravel pit N of Winchell Road, Granville, 28 Jul 1989, *Sorrie* and *Lovejoy 4803* (NEBC). Hampshire County: Sandy, low area on Plain Road, Hatfield, 30 Aug 1976, *Ahles 82399* (CONN). Middlesex County: Round Pond, Tewksbury, 9 Sep 1901, *Pease 111* (NEBC); Sphagnum bog, border of Round Pound, Tewksbury, 18 Sep 1909, *Fernald s.n.* (CONN). Norfolk County: Narrow open fen bordering small pond behind Haemetics building, with *Lycopodiella appressa*, *Drosera rotundifolia*, *Juncus canadensis*, and *Eleocharis tuberculosa*, "peatland morphotype", Braintree, 18 Sep 2001, *Haines and Lubin s.n.* (GH); Low sand margin of Ponkapog Pond, among sedges, Canton, 1 Aug 1908, *Ware 652* (SCHN); Purgatory Swamp, Dedham, *Faxon s.n.* (GH); Wellesley, 22 Sep 1909, *Wight s.n.* (SCHN). **New Hampshire.** Carroll County: Sandy strand of Ossipee Lake, Ossipee, 2 Sep 1936, *Weatherby 6874* (NEBC); S shore of Ossipee Lake among the sedge mat, Center Ossipee, Ossipee, 31 Aug 1975, *Hellquist 11010* (NASC). Chesire County: Shore of Pond, Jaffrey, 22 Sep 1894, *Deane s.n.* (SPR). Strafford County: Open floor of abandoned borrow pit, growing with *Rhynchospora capitellata*, *Muhlenbergia uniflora*, *Viola lanceolata*, *Schizachyrium scoparium*, *Alnus incana*, *Lycopodiella appressa*, and *L. inundata*, ca. 54 m elev., Lee, 10 Oct 2002, *Haines*, *Lubin*, *and Abair s.n.* (GH) **New York.** Hamilton County: Shore of East Stoner Lake, 18 Aug 1934, *Muenscher and Clausen 4113* (GH). **New Jersey.** Borough County: Closter, *Austin s.n.* (GH). **Rhode Island.** Providence County: Wet fields, 27 Aug 1892, Providence, *Collins* s.n. (GH). Washington County: Damp sands near Grace Point, Block Island, New Shoreham, *Fernald*, *Long*, and *Torrey 8387* (NEBC). **Vermont.** Windsor County: View Pond, Woodstock, 31 Aug 1921, *Kittredge 3a* (NEBC); Edge of View Pond, South Woodstock, Woodstock, 31 Aug 1921, *Kittredge B807* (NEBC).

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FIGS. 1–3. *Lycopodiella ×gilmanii* and *Lycopodiella appressa*. 1. *Lycopodiella ×gilmanii*, specimens demonstrating common morphotype with tall strobili (relative to total upright shoot height) and ascending sporophylls. 2. *Lycopodiella ×gilmanii* sporophylls, note the slender teeth near base. 3. *L. appressa* sporophylls, note that when teeth are present, they are short and broad.

The epithet has been chosen to honor Arthur Gilman of Vermont, a careful student of free-sporing tracheophytes. His expertise and tireless responses to inquiries has greatly assisted my studies of lycopods.

Lycopodiella ×*gilmanii* does demonstrate some variation in morphology. Most collections of *L.* ×*gilmanii* show relatively tall strobili comprising more than 30% of the total upright shoot height, a character state contributed by *L. inundata* (Figure 1). This form is found on saturated soils with high sand content, such as abandoned borrow pits and coastal outwash plain pond shores. In contrast, when *L.* ×*gilmanii* is found in hydric organic soils with extensive bryophyte cover, such as acid fens and lake-border fens, the strobilus is relatively short. This strobilus reduction in the "peatland morph" is paralleled in northeastern *L. inundata* and has been noted in Michigan for other species of bog clubmosses (Robert Preston, University of Michigan, pers. comm.). *Lycopodiella* ×*gilmanii* usually has ascending sporophylls at maturity. Rarely, however, collections have loosely appressed sporophylls until very late in the season when they spread further from the axis. The latter form has been seen from northeastern Connecticut and appears to merely represent dwarfed individuals with short upright shoots.

Lycopodiella ×*gilmanii* also appears to have two forms based on spore morphology – those with abortive spores and those with well formed spores. This suggests one of the parents may occur in two ploidy levels (likely *L. appressa*; see discussion under that species in Haines 2003). All of the variations of *L.* ×*gilmanii* are united by similarities in morphology of horizontal shoots, upright shoots, leaves, and sporophylls, spore size, and in geography (i.e., they occur within the region of sympatry of *L. appressa* and *L. inundata*). The holotype of *L.* ×*gilmanii* has a high fraction of aborted spores.

Despite previous confusion, *Lycopodiella* ×*gilmanii* is readily separated from *Lycopodiella appressa* by examination of sporophylls and horizontal stems. *Lycopodiella* ×*gilmanii* has sporophylls commonly exceeding 5 mm long with 0–2 slender teeth per margin (Figure 2) and horizontal shoots, excluding the leaves, 0.9–1.5 mm thick. *Lycopodiella appressa*, on the other hand, has sporophylls usually shorter than 5 mm long with entire margins or infrequently with a short, broad tooth on one or both margins (Fig. 3; rarely the teeth prolonged and slender) and horizontal shoots 1.2–3.5 mm thick. Further, most collections of *L.* ×*gilmanii* have ascending sporophylls at maturity, rather than the appressed sporophylls of *L. appressa*. In northeastern herbaria, *L.* ×*gilmanii* is most often labeled as *Lycopodium inundatum* var. *bigelovii* Tuckerman. Examination of the type specimen (*Tuckerman s.n.*, GH!) shows this name to be a synonym of *L. appressa*, in contradiction to the statements of Gillespie (1962), who believed the name applied to hybrids involving *L. appressa* and *L. inundata*.

Lycopodiella ×*gilmanii* is close in morphology to *L.* ×*copelandii* (Eiger) Cranfill (= *L. alopecuroides* × *L. appressa*), which also has long, ascending sporophylls at maturity. *Lycopodiella* ×*copelandii* is, however, a more robust plant with somewhat arching stems and more densely imbricate leaves (see key; couplet 4). *Lycopodiella* ×*gilmanii* is responsible for reports of

L. margueritae in New England (Bruce, 1975 – as *L.*"appressed inundata"; Angelo and Boufford 1986; and several unpublished media), a tetraploid species of the Great Lakes region (Bruce *et al.,* 1991). Though the plants are similar in overall outline, sporophyll orientation, etc., *L. margueritae* is a larger plant with thicker horizontal shoots (mostly 1.3–2.2 mm thick), wider horizontal shoot leaves (0.8–1.2 mm wide), and larger spores (mostly 58–65 μm; Bruce, 1975 and Bruce *et al.,* 1991). *Lycopodiella* ×*gilmanii* is probably also responsible for reports of *L. margueritae* from Pennsylvania (Roads and Block, 2000), but I have not yet seen specimens to confirm this.

KEY TO *LYCOPODIELLA* OF NEW ENGLAND

1a. Sporophylls tightly to loosely appressed at maturity (i.e., late August through September), the bases spreading less than 15 degrees from the strobilus axis; strobilus 3–7 mm wide inclusive of the sporophylls

2b. Sporophylls (4.6–)5–6.4(–7.1) mm long, at least some with 1 or more slender, marginal teeth 0.3–0.6 mm long; horizontal shoots 0.9–1.5 mm thick exclusive of the leaves, usually producing 1 or 2 upright shoots per segment; well formed spores mostly 48–53 μm in diameter . . . . . (rare variant of) ***L. ×gilmanii***

2b. Sporophylls 2.9–5(–5.2) mm long, entire or with a low short, tooth less than 0.3 mm long on one or both margins (rarely the teeth prolonged); horizontal shoots 1.2–3.5 mm thick exclusive of the leaves, usually producing 2–6 upright shoots per segment; well formed spores mostly 50–55 μm in diameter . . . . . ***L. appressa***

1b. Sporophylls at maturity ascending to horizontally spreading, the bases spreading 30–90 degrees from the strobilus axis (sometimes the tips inwardly curved); strobilus 6–20 mm wide inclusive of the sporophylls

3a. Leaves of the horizontal stems with entire margins; horizontal shoots very slender, 0.5–0.9(–1) mm in diameter, mostly 4.3–14(–15) cm long, each shoot segment usually with 1 upright shoot . . . . . ***L. inundata***

3b. At least some of the leaves of the horizontal stems with 1 or more slender, marginal teeth; horizontal stems thicker, 0.9–3.1 mm in diameter, 7–36 cm long, each shoot segment with 1–5 upright shoots

4a. Sporophylls ascending at maturity, the bases spreading from the axis 30–50 degrees; strobili 7–12 mm wide inclusive of the sporophylls

5a. Horizontal shoots 2.0–2.8 mm thick, somewhat arching above the substrate, commonly rooting 3.5–10.5 cm distal to the proximal-most upright shoot, usually producing 2–5 upright shoots per segment; common forms with many of the sporophylls and leaves in the proximal half of the horizontal shoot entire . . . . . ***L. ×copelandii***

5b. Horizontal shoots 0.9–1.5 mm thick, flat to the ground, commonly rooting 1.5–6.0 cm distal to the proximal-most upright shoot, usually producing 1 or 2 upright shoots per segment; many sporophylls and leaves with 1 or more evident, slender teeth . . . . . (common forms of) ***L. ×gilmanii***

4b. Sporophylls spreading at maturity, the bases spreading from the axis 70–90 degrees; strobili 10–20 mm wide inclusive of the sporophylls

6a. Strobilus representing 6–38 percent of the total upright shoot height; horizontal stems strongly arching, frequently more than 3 cm above the substrate, commonly rooting 7.5–36 cm distal to the proximal-most upright shoot; leaves of the horizontal shoots with 1–8 teeth per margin . . . . . ***L. alopecuroides***

6b. Strobilus representing 34–55 percent of the total upright shoot height; horizontal stems somewhat arching, usually less than 2.5 cm above the substrate, commonly rooting 7.0–13.5 cm distal to proximal-most upright shoot; leaves of the horizontal shoots with 0–3 teeth per margin . . . . . ***L. ×robusta***

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